Section 5 - SUPPORT SYSTEMS

Astronomical Support

Although the primary mission at MSSC is the measurement of Earth-orbiting satellites for Air Force Space Command, the accessibility and capability of its systems on Haleakala and Kihei provide a unique opportunity to support the astronomical community. As an example, MSSC has played an important role in the discovery and follow-up observation of asteroids. Two of these asteroid tracking systems, done in conjunction with the Jet Propulsion Laboratory (JPL), are the Jet Propulsion Laboratory Charged-Coupled Device (JPLCCD) and the Near-Earth Asteroid Tracking (NEAT). The systems have provided thousands of measurements of new and previously discovered asteroids to the Minor Planet Center (MPC) at the Smithsonian Astrophysical Observatory.

Sky Charts

Sky charts can be generated with the UNIX program Xephem, which is currently running on the OCS Control console. Xephem allows the user to display the sky at any epoch. Objects up to +30 can be displayed. Displayable objects include, stars, planets, NGC objects, Messier objects, radio sources etc. User supplied lists of objects can also be displayed. In addition to Xephem, the MSSS library has the SAO Catalog and both the north and south volumes of the Uranometria.

Sky Surveys

MSSS does not have any sky surveys on site, but it does have Internet access which allows access to online surveys such as Digital Sky Survey and SkyView.

IR Calibration Stars

Precise infrared (IR) radiometric measurements can only be accomplished by calibrating with a catalog of accurate IR calibration stars. For visible photometry, there has long existed a series of well-known calibration star catalogs in the common astronomical U, B, V, R, and I wavebands, such as the Landolt star catalog. However, for the IR spectrum, only recent efforts to combine comprehensive ground-based measurements coupled with space-based sensors and more thorough atmospheric extinction models have resulted in IR calibration star catalogs of sufficient size and accuracy. In particular, the catalog of continuous stellar IR spectra developed by Dr. Martin Cohen and Dr. Mike Egan provides spectra irradiance values in units of watts/cm^2/µm of 422 stars from 1.22 to 35 microns with a 0.05 micron resolution and at an approximate accuracy of 2%. By convolving the transmission curve of each sensor and filter pair with the catalogued continuous stellar IR spectra, an IR calibration star catalog specific to each sensor and filter combination is generated in units of watts/cm^2. By normalizing by the irradiance of Vega and converting to magnitude, the stellar catalog magnitude for each sensor filter is computed as well.

By measuring a series of IR calibration stars at different air masses, the extinction can be computed. However, dependent on the atmospheric absorption in the filter wavebands, this extinction curve may not be linear[1] ([1] Young, A.T., Milone, E.F., Stagg, C.R., “On improving IR photometric passbands”, Astron. Astrophys. Suppl. Ser., 105, p. 259-279, (1994)).

Therefore, the IR stellar calibration procedure used is customized to the specific sensor and filter combination. Due to variations in atmospheric conditions, these calibrations need to be performed as close to the actual observations as possible. For practical considerations, most astronomers will measure responsivity, extinction, and other calibration parameters on a nightly basis.

Atmospheric Support

Atmospheric Instrumentation

The AMOS Atmospheric Instrumentation category of systems consists of an array of sensors, signal processors, and data recording computers designed to characterize the atmosphere and monitor site weather conditions. It includes a Seeing Monitor, Star Sensor, ground-level turbulence sensor, radiosonde systems, and surface meteorological sensors. This instrumentation is part of a continuing Atmospherics Characterization Program; however, it can also provide unique information for specific user requirements.

The Seeing Monitor is a device built by Hughes Research Laboratory which uses a spinning reticle wheel and two photometer channels to measure the atmospheric Modulation Transfer Function (MTF) and image size in two orthogonal directions. Outputs include the MTF and ro. The parameter varies from moment to moment and is a result of the turbulent mixing of air "cells" of different temperatures and thus different indices of refraction. The Seeing Monitor is located in the Atmospheric Sensor Package (ASP), which can be installed if required for a particular experiment, on the side Blanchard surface (i.e. folded Cassegrain surface) of the B37 1.2 Meter telescope.

The Star Sensor (Stellar Scintillometer) is a National Oceanic and Atmospheric Administration (NOAA)-built sensor which is installed in a small dome at the north edge of the AMOS site. It measures stellar scintillation as a function of spatial frequency, from which are derived the atmospheric turbulence contributions from seven selected altitudes (from 2.2 to 18.5 km) above the site. These measurements yield a value for the index of refraction structure parameter (CN2) as a function of altitude.

The ground-level optical CN2 meter consists of a receiver that measures ground-level turbulence by monitoring intensity fluctuations from a constant direct-current light source 180 meters away.

The upper air profiling system consists of balloon-borne radiosondes and a telemetry receiver with a data processing system. This system provides profiles of meteorological data (including temperature, relative humidity, wind speed, and wind direction) as a function of altitude from the surface to as high as 30.5 km (100,000 feet).

In a recent innovation, a radiosonde (without the balloon) was mounted on a light aircraft as a way of characterizing the atmosphere along a horizontal path. This technique was used for Air Defense Initiative (ADI) studies when IR arrays are used to investigate aircraft signatures.

Lastly, an array of meteorological sensors is maintained at MSSS to provide the ground-level measurement of temperature, dew point, barometric pressure, wind speed, and wind direction (RMET data). Data is sampled continuously and recorded every three minutes. Meteorological history plots are available as part of the data package if requested (see Section 2).

Communications

MSSS supports a variety of external communications including:

The Advanced Data Communications and Control Procedures (ADCCP) that carries classified AMOS/MOTIF data.

The Space Command Digital Information Network (SDIN) a full-duplex dedicated communication line supplying classified connectivity to the world-wide Department of Defense (DOD) network. This circuit is used for classified mission data and administrative traffic.

Radar circuits that bring classified or sensitive but unclassified (SBU) radar data to MSSS through four dedicated lines. Radars include the PMRF (Pacific Missile Range Facility) radars on Kauai HI, and the FPQ-14 radar from Oahu HI. Radar data is used to support radar hand off or radar target acquisition.

The Western Space and Missile Center (WSMC) teletype circuit that supports test launches from Vandenberg AFB CA. No encryption is used because this line carries unclassified data.

The T1 Microwave Link between the observatory and the Kihei office facility that provides dedicated secure TCP/IP Ethernet connectivity between the MSSS and the Boeing-Maui offices in Kihei, Maui HI. This connectivity can be used for off-site software development and remote operations.

Dedicated T3 fiber optic link secure that provides secure TCP/IP Ethernet to the MHPCC dedicated secure AMOS frame.

Internet access, available from sensitive but unclassified (SBU) systems at the field office and the observatory.

Dial-up classified and sensitive but unclassified (SBU) access, supported by a number of hosts at both the MSSS and the field office.

Special communication needs. Recent examples include aircraft communications by UHF radio. Classified special communications, both voice and data, can be made with the STU-III.

MSSS systems that play key roles in communications include the MIDAS and IDPS software projects. These are described below.

Communications Circuits

The value of surveillance data in terms of defensive reaction potential decreases rapidly with time after the event is recorded. The MSSS has developed a system of software and hardware to deliver surveillance imagery in near real time to the analysts (at Peterson Air Force Base, Colorado) who need the data.

The Advanced Data Communications and Control Procedures (ADCCP), a new communications circuit was implemented in 1994 to provide direct secure data connectivity from MSSS to Cheyenne Mountain Air Force Base. It is a standardized protocol used by external sites to interface with Cheyenne Mountain. The new circuit operated initially at a rate of 9.6 kb per second. The capacity will increase to 56 kb and higher after Cheyenne Mountain software modifications.

After data is collected at the MSSS and processed, image data is handed off directly from the Image Data Production System (IDPS-software) to the MOTIF Integrated Data Application System (MIDAS-software). MIDAS manages the external communications and segments the image data for transmission by the protocol converter, a Simpact(tm) communications device. The Simpact device handles low-level ADCCP protocol communications to Cheyenne Mountain.

The image data is then processed sequentially by five separate computer systems within Cheyenne Mountain before being downloaded via a T1 link to the analysis work stations in the Combined Intelligence Center (CIC). The automated sequence of communications processing is transparent to the end users and enables image data to reach analysts in the NORAD/US Space Command CIC (Peterson AFB) in near real time. This feature represents a significant enhancement to the Maui Space Surveillance Site operational capability.

Aircraft Communications

Special experiments requiring prescribed flight paths of cooperative aircraft can be conducted. Control directly by AMOS personnel is by two installed (primary and backup) 20 watt AN/GRC-171 UHF radios out to a useful reception range of ~250 nautical miles.

Electronics Lab

The MSSS electronics lab is located in the MSSS facility and is primarily used for corrective maintenance of computer and electronic site assets. Technicians are available during normal work hours to help diagnose and repair computer, video and electronic problems. Arrangements can be made for preparation and assembly of custom cabling, including fiber optic cables. The electronics technicians are also responsible for installation of power sources (up to 440 VAC @60 A)

Note that the MSSS maintains a limited stock of parts for standard cables and simple electronic components, but no specialized electronic components are stocked.

Test equipment available for use includes:

- Logic Analyzers
- Oscilloscopes
- Multimeters
- ESD and Flat-Pack Soldering Stations
- Fiber Testing and Connector Kits
- Network Sniffer
- Spectrum Analyzer

Lasers

Many kinds of lasers have been installed on Maui ranging from an "F center" laser of very low output to the large ruby oscillator-preamplifier-main amplifier system. No weapon class lasers have ever been located on Maui. Nevertheless, strict rules have been implemented concerning eye safety and to avoid accidental damaging of critical sensors on satellites. No laser can be allowed to radiate when there is any likelihood of illuminating a target for which no permission has been granted by the satellite owner.

Laser beams can be directed by the 3.6 Meter telescope or either of the two beam expander afocal telescopes, the LBD and the BD/T. All are coudé systems, so the laser equipment can be rigidly mounted in the observatory building below the telescope floor level.

Site Laser Systems

Table 5-1, AMOS Active Lasers

Type	*Manufacturer*	*Wavelength (mm)*	*PRF / CW*	*Energy / Power*	*Pulsewidth*
CO_2	Textron	11.3	10 - 30 Hz	9 Joules	6 μs
CO_2	Laser Technics	10.6	10 Hz	5 Joules	100 ns
Nd:YAG (2)	Quantronix	1.064	CW	18 Watts	-
Nd:YAG	Holobeam	1.064	CW	500 Watts	-
Alexandrite	NASA-GSFC	Tunable: 0.720 - 0.790	10 Hz	0.35 Joules	50 ns
Argon	Coherent Model 70	0.514	CW	5 Watts	-
Argon	Spectra-Physics Model 171	Line-Tunable: 0.454 - 0.529	CW	6 Watts @ 0.514 μm	-
Krypton	Spectra-Physics Model 170	Line Tunable: 0.521 - .799	CW	4.7 Watts @ 0.647 μm	-

HI-CLASS

The High Performance CO2 LADAR for Space Surveillance (HI-CLASS) is a frequency agile, heterodyne transceiver consisting of a 30 J, 30 Hz, pulsed TEA CO2 laser and a quadrant detector receiver boresighted to the transmitter. The T/R switch is a polarizer. HI-CLASS has its own AIM driven track lag mirror and uses the VLT/LBD as its visible tracking system . The HI-CLASS TEA laser and receiver can switch between a pulse tone or pulse burst (mode locked) waveform and between short pulse (5 micro seconds) or long pulse (15 micro seconds) operation in 30 seconds. Transceiver line switching at 30 Hz is achieved by coordinated control of gratings in the TEA laser and the local oscillator cavities. Uses for HI-CLASS include measurement of range and Doppler shift with pulse tone, LADAR imaging with the 1.5 ns micropulses separated by 40 ns in the pulse burst mode, and DIAL technique LIDAR in the line agile mode of operation in either pulse tone or burst mode.

User Furnished Laser Systems

Lasers and their auxiliary equipment, if handling CLASSIFIED data, so called "Red" equipment, must have the installation approved by the resident TEMPEST Officer. Potential laser users should be acquainted with several fundamental specifications necessary for operation of equipment on Haleakala:

- Regarding safety, electrical, optical, and environmental conditions, consult us early in your planning.
- Site conditions: The pressure altitude of over 3 km (10,000 ft) means:
    - Cooling fans adequate at sea level probably will NOT furnish enough air flow to cool chillers, etc.-consult us.

    - The voltage breakdown strength of gaps and electrical leakage paths across insulators is lessened. A rough rule is that at 3 km altitude, the voltage which will break down a gap is only 2/3 as much as at sea level if both are at the same temperature.
    - Corona is an electrical noise problem. No detectable corona at sea level does not guarantee corona free operation at the Observatory.
- Electro-Magnetic Interference: Remember that the Observatory has many very high-gain amplifiers following relatively unshielded detectors because of their optical access requirements. Therefore laser systems must be built with care to avoid emission of electrical radiation as well as noise on the power lines.
- Shielding is required: Military aircraft specifications offer guide-lines to follow.
- TEA lasers and Excimer Lasers: These pulsed devices are particularly noisy when their electrodes are triggered, requiring special care with grounding. Consult us for further guidance.
- Acoustical noise is a potential health hazard in the relatively confined environment of the Observatory.

Typically, a VE's laser would be located in room 72, the coude path room for the BD/T or in one of the six available AEOS coude experiment rooms. They may be mounted on the existing optical benches in these rooms. For laser operations, one must have an ophthalmic examination including fundus photography, on record, and one is required to have the safety training specified in ANSI standard 136.1 and AFOSH 161-10 for the safe use of lasers. The Boeing -Maui Safety Officer can supply this training.

If your experiment requires the use of special chemical agents, consult the Boeing - Maui Hazard Communication Program (HAZMAT). Be sure equipment is properly labeled and any Government Furnished Equipment (GFE) is so identified.

Mission Support Software (MSS)

Software developed for the control of the telescopes matches the Kepler orbits of satellites to the pointing geometry of the telescopes on the rotating earth. Measurable effects, including atmospheric refraction and the deviation of the earth from a true sphere are considered. The mount control computers update calculations to inform the telescopes where to look. To acquire and track a selected object, requires a state vector at a precise time. Using the laws of orbital motion, an ephemeris can be calculated. This is a table of angular (azimuth and elevation) position and slant range as a function of time. Coupled with sun position information the illumination of the object can be calculated. The fundamental equations for performing these calculations reside in the Mission Support System software. This software is contained in the MOTIF Integrated Data Application System (MIDAS).

The Mission Support System (MSS) consists of software that supports the requirements of mission allocated telescopes and sensors. The software is used for the following three major tasks:

- The Data Base Management Task (DBM)
- The Mission Preparation Task (MPT)
- The Data Reduction Task (DRT)

The DBM task consists of software that manages the I/O files that are used as data bases by MSS software systems. Some DBM programs operate in real time while others are operator activated and controlled.

The MPT task consists of software that performs the mission planning and preparation functions for the Maui Satellite Surveillance Site (MSSS) operations. MPT software is run daily before operations for routinely tasked objects. The software may be run for specific user missions to determine feasibility of the proposed observations (AESOP program, see below).

The DRT task consists of software that performs the reduction of data collected on the History tapes by the MCS software.

The Mission Preparation Task

The software required to support the MSSS for operations and the Kihei Field Office for development and documentation, is executed daily to accomplish the Mission Preparation Task (MPT). The general function of the MPT software is to generate the information, data files and listings necessary to plan, schedule, and perform the operations of target acquisition, tracking and data collection and the software has useful simulation capability. Printouts of key interest to users are described below. In addition to printouts, electronic versions of each of the 3 MPT data products are available. These e-versions are available to users as Excel spread sheet files.

The universal date and time window for the evening's operations is the first input required by the MPT procedure, which executes a series of programs to produce the operational mission plan. The user may request entry of specific metric tasking for the object of his mission. In addition, if there are security considerations, an ATN (AMOS Test Number) will be used for tracking in lieu of the object number.

AMOS Ephemeris Satellite Orbit Predictor (AESOP) Program

A run of this program provides information about a known satellite concerning the availability of its being tracked in a given time window under specified illumination conditions. If the given window does not include a pass of the specified satellite, the window must be shifted or enlarged. The predictions are kept accurate by updates of their element sets. The program is particularly useful for visiting experimenters who wish to observe selected satellites during their stay on Maui.

The printout of program AESOP presents the following parameters for each day specified:

- Universal date (MM/DD/YY)
- Corresponding modified Julian day number
- Time of sunset at Observatory (UT HH:MM:SS)
- Time of end of evening twilight (UT)
- Time of sunrise (UT)
- Beginning and end of window 1 (HH:MM)
- Azimuth of sun at middle of window 1 (degrees)
- Elevation of sun at middle of window 1 (degrees)
- Azimuth of moon at middle of window 1 (degrees)
- Phase of moon at middle of window 1 (degrees)
- Beginning and end of window 2 (HH:MM)
- Azimuth of sun at middle of window 2 (degrees)
- Elevation of sun at middle of window 2 (degrees)
- Azimuth of moon at middle of window 2 (degrees)
- Phase of moon at middle of window 2 (degrees)

(all angles relative to the MSSS)

The AESOP program contains two sections. The first section lists each satellite in the order input, pass parameters, and a notation if the pass is scheduled or no pass was found. The following section, titled “accepted passes” lists each pass that meets the specified elevation and lighting constraints, in a time ordered sequence. The paper print out of AESOP contains both sections, useful to see what passes are accepted and rejected and for what reason a pass is rejected. The Excel electronic version of AESOP uses only the accepted section. This is useful for sorting and statistical information on satellite passes, for example, the number of passes in a given period, the maximum and minimum culmination elevation, and the average length of a pass.

Satellite Ephemeris Preparation (SATPREP) Program

Specific passes or data collection missions may require an ephemeris, which is a table of pointing information tabulated as a function of time. The printout has range, azimuth, elevation, phase angle, and mount angle data points at specified time intervals that may be important in planning and scheduling considerations. The SATPREP program printout consists of 3 parts. The first part is a single title page listing program input parameters:

- Starting date
- Starting time in UT
- Rise elevation in degrees
- Ephemeris listing time step for each site
- Number of ephemeris listing for each site
- Constrained mount azimuth for each site
- Ephemeris listing page limit
- Pass search time limit

The second part is a single page listing the initial conditions of the pass. The data printed on this page includes:

- The ATN to be generated
- The UT date of the pass
- The modified Julian date of the pass
- The revolution number of the pass (if an SCC element set was specified for input)
- The age of the element set (if specified)
- The printout label for this case
- A column of the SCC element set data items (if specified)
- A column of the Earth Centered Inertial (ECI) state vector and time defined at mount motion
- A column of the Earth Centered Rotating (ECR) state vector and time defined at mount motion
- The orbit's apogee and perigee height

The final part consists of a sequence of ephemeris listings. Each page has a header with the following data items:

- The label
- The name of the site
- The sunset time (if the pass is closest to sunset), or morning twilight (if the pass is closest to sunrise)
- The ATN to be generated
- The UT date of the pass
- The mount azimuth in degrees, minutes, and seconds

- The shaft angle encoder (SAE) reading for the mount azimuth
- The evening twilight (if the pass is closest to sunset), or sunrise (if the pass is closest to sunrise)
- The revolution number of the pass (if an SCC element set was specified for input)
- The age of the element set (if specified)

A line of ephemeris data is printed for each time interval during the pass. The first block for each pass is printed out in 10 second intervals for finer resolution at the time of mount motion. Each line consists of 10 columns of data as follows:

- The universal time in HH:MM:SS format. An 'M' is appended to the time at mount motion and a 'C' is appended to the time of culmination.
- The slant range of the object from the site (in kilometers).
- The azimuth of the object as seen from the site (in degrees).
- The elevation of the object as seen from the site (in degrees).
- The polar axis angle of the telescopes, (1.2 Meter and 1.6 Meter), the gimbal azimuth axis (LBD), or the major axis angle (BD/T)(in degrees).
- The declination axis angle of the telescopes, (1.2 Meter and 1.6 Meter), the gimbal elevation axis (LBD), or the minor axis angle (BD/T) in (degrees).
- The polar axis velocity of the telescopes, (1.2 Meter and 1.6 Meter), the gimbal azimuth axis velocity (LBD), or the major axis velocity (BD/T) (in degrees/second).
- The declination axis velocity of the telescopes, (1.2 Meter and 1.6 Meter), the gimbal elevation axis velocity (LBD), or the minor axis velocity (BD/T) in (degrees/second).
- The satellite illumination ('LIT' or 'DARK').
- The sun-satellite-earth phase angle (in degrees).

This printout continues until the object descends below the specified rise elevation.

These lines of ephemeris data may be written to a file if specified. This would provide a file whose records consist of the ASCII text that is printed at each time step and is useful for creating tables or graphs.

The Excel electronic version of SATPREP contains the last section of the print out. This contains the entire sequence of ephemeris listings.

Mission Planning (MPLAN) Program

The MPLAN output is a multiple part listing to be used by operations personnel in performing the nightly metric operations of acquisition, tracking and data collecting. There are 9 parts to the listing:

- Part 1 is a title page.
- Part 2 input parameters: data, time window, and tasking parameters.
- Part 3 is a printout of the contents of the Daily Tasking File (DTF).
- Part 4 is a solar and lunar ephemeris page.
- Parts 5 and 6 are printed out as the program schedules tasked objects. The objects are scheduled from highest priority (lowest number) to lowest priority; parts 5 and 6 repeated for each priority level.
- Part 7 lists scheduled passes in time sequence. The format and data values are the same as in part 6.
- Part 8 is a set of work sheets to be used by the MCS console operators. The scheduled passes are listed in time sequence and data values listed include object number and tasking category, rise and set times, shadow transition times, culmination time and elevation, and mount azimuth. There are data boxes for element set number

and age, polar and declination axis offsets at the time of acquisition, estimated visual magnitude, and the date and time of the acquisition.

- Part 9 is a set of extra blank work sheets.

VEs will typically find the electronic version of AESOP most useful for planning purposes. AESOP can be used to generate opportunities on a large number of satellites for long periods of time. For example, a user may be interested in looking at all objects in a curtain class or orbit of satellites over a 30 day period. The electronic version of AESOP will allow a user (or mission planner) to sort and filter passes and calculate the number of opportunities that meet mission constraints. SATPREP is most often used during the actual mission and is generated on only a single satellite at a time. The SATPREP program is generated for each mission a few hours prior to the pass over MSSS. The MPLAN program is most often used internally at MSSS to support Space Command metric operations. The electronic version of this program can be modified for user programs to provide information on multiple deep space satellite passes over MSSS.

Multimedia Support

In addition to the raw and processed data resulting from a mission, in many cases VEs have found data reporting enhancement capabilities valuable aids to the presentation of their work. Visiting experimenters may elect to have carefully produced video tapes showing their apparatus being installed on the chosen telescope, combined with footage of the observatory scene, coupled with captioned excerpts from the video data actually obtained during the mission, scripted and narrated to demonstrate to the world exactly what happened when the experiment was performed. Photographic documentation of details of the installation may be used in printed reports and journal articles resulting from the user's activities on Maui. The graphics facility can generate detailed quality overhead projection foils. Stock digitized images of our standard telescope and sensor packages may be included to furnish the background for depicting an installed experimental apparatus.

Video Production

Complete broadcast quality video production services are available for presentations of data, safety, training, and experimental details including scripted and narrated sound tracks. Program design, story boarding, on-location shooting, incorporation of data imagery including split screen comparisons and animation techniques may be called upon for the enhancement of the user's message. Animation of optical diagrams has been used to clarify difficult explanations. The video production facility has access to years of past data tapes to compare with the most recent events.

Particular equipment includes 3/4 inch U-matic SP editing and switching capabilities, digital capability for titling, animation, and special effects. Audio capability includes an 8 channel mixer, sound booth, reel-to-reel recording and editing. Dubbing between 3/4-inch U-matic format and the 1/2-inch VHS format may be chosen. Direct video photography using a Sony professional 3/4-inch U-matic portable camera is available.

Photography Services

Skilled photographic services are available to the user. A large variety of still picture recording equipment including a large format copy camera, a 4 X 5, and a 2-1/4 square Hasselblad is available. Nikon quality lenses having fields of view ranging from 8.2^{o} to 100^{o} for the Nikon_{TM} 35-mm single-lens reflex camera bodies provide suitable coverage under widely varying conditions.

Graphical Arts Services

Digital computerized presentation capabilities overlaid with hand drawn artistic renderings give the final touch to overhead projection foils and posters as well as line illustrations for technical papers.

Stock line art of various views of the telescopes and their sensors is available. Alterations and additions may be visualized using digitized versions of the original art.

Optical Engineering Support

Optical engineering and alignment activities at MSSS are performed primarily by the Optics Group. The group is available to assess technical issues and evaluate beam trains using PC-based lens design programs. This allows experimenters and asset users to optimize optical performance as well as consider on-site modifications. The group also provides alignment support for all the major telescopes, performs systems integration activities, and maintains optics labs for instrument check-out and experimental work.

Optics Lab

The MSSS optics labs are located in the AEOS facility and are used for a wide variety of engineering and scientific purposes. These include functional check-out and calibration of sensors prior to telescope installation, equipment repair, experimental breadboarding and evaluation of optical components. Optical benches ranging from 4’ x 8’ to 5’ x 16’ with vibration isolation are available in all the labs. Standard optical bench components (e.g. mirror mounts, translation stages, posts and platforms) are stored in the labs. In addition, a large selection of optical components including mirrors, splitters, ND filters, notch filters, polarizers and beam expanders are available.

Test equipment available for use include:

- Zygo 4” Fizeau interferometer
- Itek laser unequal path interferometer
- WaveFront Sciences CLAS-2D Shack Hartmann wavefront sensor
- K & E alignment scopes
- Wild T3000 autocollimating theodolites
- Astronomical telescopes (8” to 14”)

MSSS Coating Facility

The Optics Group also maintains the MSSS Coating Facility within the AEOS facility. The facility is managed by Boeing - Maui under the direction of AFRL. The facility contains a 20” Veeco vacuum chamber, a 96” Stokes chamber, monitoring equipment, flow benches, cleaning areas and storage cabinets. The systems provide an on-site capability for re-coating virtually all the telescope mirrors, transfer optics and auxiliary components.

The 20 inch 7760 Series Veeco vacuum chamber system is designed to deposit high quality coatings and dielectric overcoats. The unit consists of a four stage oil diffusion pump, a mechanical pump, a chamber consisting of a bell jar and hoist, and a controls system. Base metal coatings include aluminum, gold and silver. Protective overcoat materials include magnesium fluoride and silicon monoxide. Current capability is limited to single layer overcoats.

The Stokes 96 inch vacuum chamber is a horizontally oriented unit designed for depositing metal coatings on large circular mirrors. The unit has a split tank with each section independently mounted on a rail system. The main section contains the filament assembly which is powered by a mobile 40 KVA power panel. The frame supporting the removable head also supports the diffusion pump, baffle and vacuum control panel. The system is equipped with a Stokes #412-10 Microvac pump that initially rough pumps the system and backs a CVC 20” diffusion pump during high vacuum operation. Mounted to the diffusion pump is a multi-coolant baffle which is used to condense and trap vapors and prevent back-streaming of pump vapors. The chamber has been used to successfully re-coat the 1.2 m primaries and the 1.6 m primary.

Safety, Health, and Environmental Affairs

The primary mission of the Safety, Health, and Environmental Affairs Department (SHEA) is to promote a safety awareness culture and to preserve the environment while maintaining safe and compliant operations. As an Air Force Installation, the MSSS is required to comply with all applicable Federal, State, Local and Air Force laws and regulations.

The site is unique in that it poses challenges to a SHEA program. O&M and R&D operations:

- are conducted at a 10,000 ft elevation;
- occupy space on state owned land that is federally leased;
- are home to endangered and threatened species;
- are adjacent to Haleakala National Park; and
- border areas of native Hawaiian cultural resources.

In parallel with these challenges, the main goals of Boeing and the AFRL are to conduct safe workplace operations and to be recognized stewards of the environment.(meet and exceed environmental requirements?) The SHEA dept. recognizes that the regulations appear to be restrictive at times however, preplanning and working with your POC can overcome these restrictions. Please don't wait until the last minute.

Health and Safety Program

Safety is everyone's responsibility. Anticipating, recognizing, and reporting potential hazards are the keys to preventing accidents. In order to resolve any issues that may arise as a result of your activities on site, some basic questions (not all inclusive) should be asked:

- Will chemicals be used in the operations?
- What type of training do I need to perform my tasks? Have I received this training?
- Do I have the appropriate safety equipment?

The list below includes but is not limited to elements of a health and safety program however, this gives you an idea of who and what SHEA deals with regularly:

- Noise, lasers, HAZCOM, fall protection, emergency preparedness, electrical safety
- Applicable Regulations: OSHA, AFOSH, NFPA, NEC
- Lead Agencies: HIOSH, Maui County Fire Dept., AFRL, FAA

Environmental Compliance Program

With the broad band of environmental protocols applicable to the site, susceptibility to non-compliance situations may occur. So, it is not surprising that an agency like the EPA has visited the site. In order to resolve any issues that may arise as a result of your activities on site, some basic questions (not all inclusive) should be asked:

- Do I need permits for my equipment or processes? (long lead times)
- Is there a potential for generating hazardous waste? Solid waste? Wastewater?
- Is my work going to impact the historic/cultural sites near the site?

The list below includes but is not limited to elements of the environmental compliance program however, this gives you an idea of who and what SHEA deals with regularly.

- Air emissions, hazardous waste, lead and lead compounds, wastewater, Hawaiian artifacts
- Applicable Regulations: RCRA, NEPA, CAA, CWA, TSCA, DOT

- Lead Agencies: EPA, Hawaii Dept. of Health, DLNR

Towards achieving the goals stated above, we ask that you work with the POC who is coordinating your arrival on site. It is important to the AFRL and Boeing that the transition into the facilities and the ongoing operations is seamless. Once on site, the SHEA dept. will support your stay to ensure that work is performed in a safe manner and protection of the environment is maintained.

Visiting R&D Experiments Guidelines

Many complex experiments have been successfully performed by visiting experimenters involving the multitude of resources available at AMOS. Although the location of the site is thousands of miles from the mainland, the common air shippers perform well; shipping times for most items is seldom more than a few days. Nevertheless, contingency planning is very important and frequent contact with your AMOS sponsor is urged as your experiment time approaches. Machine shop facilities and electronics parts are limited at the observatory. Visiting experimenters are advised to bring their own hand tools, suitably identified, for use during their stay at AMOS. Section 7 of this manual describes the process for soliciting use of the AMOS facilities and instrumentation by users requiring measurement or visiting experiment programs.

Frequent visitors and those working at the observatory for more than two consecutive days are required to attend safety briefings on

- Driving;
- Mechanical, Chemical and Electrical Procedures and;
- Laser Radiation Safety (if appropriate)

in accordance with site safety policy.

Chemical Use

If the experiment requires the use of special chemical agents, consult the *Boeing HAZMAT Guide*, HAZMAT.pdf, part of the Hazard Communication Program. Equipment must be properly labeled and any Government Furnished Equipment (GFE) items so identified.

Laser Equipment

Visitors planning laser-based experiments are urged to observe the cautions and recommendations to be found in this section for the design and preparation of their laser equipment prior to shipment to Maui. For laser operations, visitors must have an ophthalmic examination including fundus photography on record, and are required to have the safety training specified in ANSI standard 136.1 and AFOSH 161-10 for the safe use of lasers. The Boeing Safety Officer can supply this training.

HAZMAT

If one is handling potentially hazardous material, all actions are required to follow HAZMAT procedures as defined in the HAZMAT.pdf document.

Security

Boeing North American, Inc. is responsible for visitor control at the MSSC. All visits shall be coordinated well in advance of the proposed visit to allow ample time to process and obtain appropriate approvals. A point-of-contact will be established for all visits and experiments conducted at the MSSS. The point-of-contact shall be a Maui resident point-of-contact. The point-of-contact is responsible for coordinating, obtaining approval and hosting the visit, experiment and/or project.

Visit Requests

All classified visits to the Maui Space Surveillance Complex require a visit request prepared in accordance with the National Industrial Security Program Operating Manual (NISPOM) Chapter 6.

The clearance certification for all facilities shall be addressed and forwarded via mail or fax as follows:

Detachment 3, 18 SPSS		*or*	AFRL/DEBI
Boeing North American, Inc./OMAN2	*or*	Litton/PRC, Inc.	
Attention: Visitor Desk			
535 Lipoa Parkway Suite 200	FAX	808-874-1600	
Kihei, Maui HI 96753	Voice	808-875-4500	

Visit Authorization Requests

The Visit Authorization Request shall be in accordance with the NISPOM, Chapter 6, and at a minimum, contain the following information:

- Visitor's organization name, address and telephone number, assigned CAGE Code if applicable and certification of the level if the facility security clearance.
- Name, date and place of birth, and citizenship of the employee intending to visit
- Certification of the proposed visitor's personnel clearance and any special access authorization required for the visit;
- Name of person(s) to be visit
- Purpose and sufficient justification for the visit to allow for determination of the necessity of the visit, and
- Date or period during which the visit is to be valid.

Visitor and Point of Contact Responsibilities

All visitors shall have a Maui resident point-of-contact (POC). POCs will be from Det 3, 18 SPSS, AFRL, Boeing, Litton PRC, Textron Systems or Thermotrex.

It is the responsibility of the POC and visitor to ensure:

- A *Visitor Notification/Coordination Form* is processed through the Visitor Desk a minimum of three days prior to visit. See Appendix F.
- visitor(s) bring proper identification
- visitor(s) sign the visitor register upon arrival each day at each facility for the duration of the visit
- visitor(s) wear visitor badges in a visible location at all times
- ensure visitor(s) photographic, programmable and recording equipment has approval for use
- visitor(s) are escorted where required
- visitor(s) are not left in the facility after hours without approval to lock and alarm the facility
- visitor(s) are not granted access to computers without approval and briefings
- visitor(s) badges and keys are returned to the Security Office or Visitor Control Desk at the end of the visit

Access to Classified Material

All visits and/or experiments where access to classified data or material is anticipated will require a Visit Authorization Request from the Security Office of the proposed visitor's company/organization.

Request for Use of Equipment

No software, photographic, programmable, or recording equipment is permitted at the MSSS without prior approval This includes, but is not limited to, personal film cameras, camcorders, audio tape recorders, and cellular telephones. Visitors desiring to bring equipment for use at the MSSS should notify the point-of-contact well in advance to coordinate and process approvals. Approvals will be obtained by processing a *Request for Use of Equipment,* through the point-of-contact, to the Security Office. Please refer to Section 7 for information concerning shipping and receiving of equipment.

Request for Area Access

The POC will process all request for access for AEOS, Dairy Road, MSSS, Premier Place and RME through the Security Office. Area access will be based on the visitor(s) clearance and need-to-know. Approvals will be obtained by processing the *Request for Access* through the Security Office. See Appendix F.

Request for AIS Access

The POC will process all request for access to the unclassified, sensitive but unclassified (SBU) and classified computers. Access to computers will be based on the visitor(s) clearance and need-to-know. Approvals will be obtained by processing the *AIS Access Authorization and Briefing Form* through the Security Office. See Appendix F.

Special Data Handling

All data processing equipment that will be used by a visiting experiment program must be itemized and described prior to shipment to AMOS. An authorization to use user-provided ADP equipment will be required prior to the transport of the equipment to the site.

If the data to be processed, generated or stored is CLASSIFIED, the data handling equipment (now considered "RED") must meet the AMOS TEMPEST Officer's approval. Stored CLASSIFIED data must be handled in accordance with the instructions of the Facility Security Officer (FSO). Upon completion of the visitor's experiment, the CLASSIFIED data, whether on diskette, video tape, digital tape, exposed photographic material, or other media must be brought to the Kihei Security Office by Boeing's official secure courier. The data will then be prepared for transport to the visitor's designated Security Officer, with proper documentation, wrapping and mailing instructions. CLASSIFIED data must not be allowed to remain in integral data storage devices, such as PC hard disks, for unsecured shipment back to the visitor's facility.

Timing System

The AMOS Timing System maintains synchronized time to within 5 microseconds of the UTC (Coordinated Universal Time) at the U.S. Naval Observatory (USNO). GMT or Greenwich mean time, UT or Universal time, and Z or Zulu time are the same. They refer to the time on the Greenwich meridian. UTC or Coordinated Universal Time is essentially the same, but determined by the U. S. Naval Observatory (USNO) and broadcast by WWV and WWVH and used by the GPS.

The Timing System may be logically separated into three subsystems; Generation, Synchronization, and Distribution. The purpose of the generation subsystem is to produce an extremely accurate reference frequency from which other needed frequencies and time codes can be generated for distribution to the mounts and instruments needing them. Synchronization matches the generated frequency to the USNO standard clock. GPS and WWVH are used for synchronization sources.

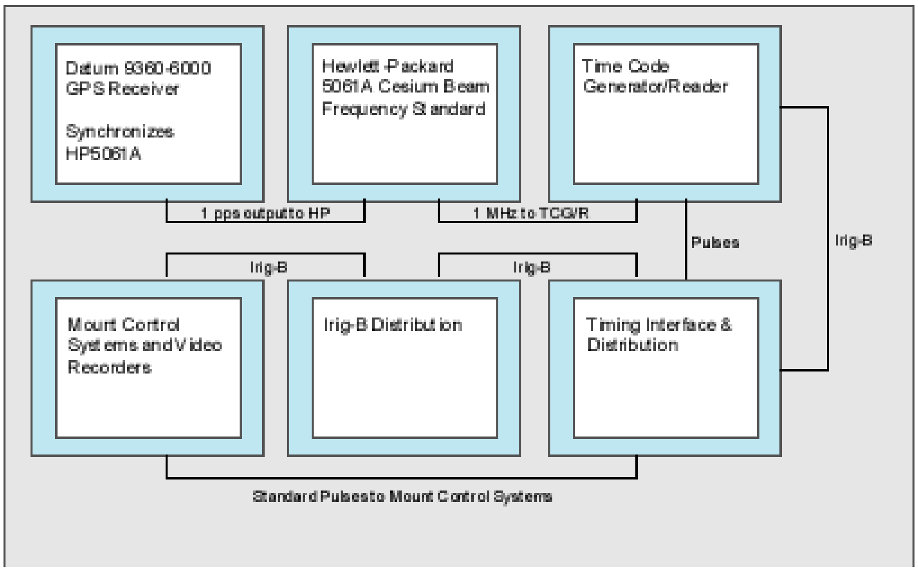

Figure 5-1, AMOS Timing System Schematic

The principal source of USNO time is the constellation of Global Positioning Satellites (GPS). When the satellites are available the AMOS master clock function is a Datum, Inc. model 9390-6000 GPS Receiver. The GPS reference is within 100 nanoseconds of the UTC time at the USNO when it is time locked on four GPS satellites. The Hewlett-Packard Model 5061A Cesium Beam Frequency Standard maintains the time reference, which is synchronized to the GPS receiver. The time reference frequency is passed to a Systron Donner 8150 Time Code Generator/Reader (TCG/R), the main element of the Distribution System. The TCG/R supplies a coded pulse to the Mount Control Systems for time-tagging data and provides a variety of time codes including IRIG-B and standard pulse rates to instrumentation, camera systems, and recorders.

Figure 5-1 is a block diagram of the AMOS Timing System which also provides timing pulses for user applications. To find the Maui time of an event to occur at a given GMT, subtract ten hours from the UTC, GMT or Z time. The local time for Maui, and the entire State of Hawaii, is Hawaiian Standard Time (HST). Hawaii does not have Daylight Saving Time.

Video Systems

VIDEO CAMERAS					
Mfgr.	MODEL	TUBE	CONFIG>	Cath Dia.	SYSTEM USING
Scanco	SC-401	Vidicon	ISIT	40 mm	MATS
Scanco	SC-401	Vidicon	ISIT	40 mm	AATS
RCA	TC1040/HC	Vidicon	ISIT	16 mm	CIS
Scanco	SC-25	Vidicon	ISIT	25 mm	LLLTV
Cohu	2856	Vidicon	ISIT	16 mm	AMTA boresight
RCA	TC1040/H	Vidicon	ISIT	16 mm	LBD
RCA	TC2500	Silicon Matrix Vidicon	Ultricon	2/3 inch	(spare)
RCA	TC1040/H	Vidicon	ISIT	16 mm	1.6-boresight
RCA	TC1040/H	Vidicon	ISIT	16 mm	BDT
Photometrics		(CCD-Kodak KAF-1400)	(special masks)		PHIAT
Pulnix	TM 745	(CCD)	(not a tube)	16 mm diagonal	MAIS
MITLL	(special)	(CCD)	TE cooled	3 mm sq.	ADONIS

VIDEO RECORDERS AND REPRODUCERS			
Mfgr.	MODEL	QUANTITY	TAPE SIZE
Sony	VO-9600 (VCR)	10	All use NTSC (Color) 3/4-inch U-MATIC format tape
Sony	VO-5850 (VCR)	4	
Sony	VO-2611 (VCR)	1	
Panasonic	NV-9240XD (VCR)	2	

Figure 5-2, AMOS TV Cameras and Recorders

The AMOS/MOTIF facility makes extensive use of standard NTSC video for acquisition, fine tracking, and imagery of visible targets. This has resulted in a video system consisting of an assortment of cameras, monitors, and solid state detectors (CCDs), digital processing equipment, automatic TV trackers, and broadcast studio quality video tape recorders. The video system operates within the US NTSC television standards. This system is compatible with standard U.S. video equipment operating at 525 lines/frame and 60 fields/second.

The table in Figure 5-2 lists the present inventory of video cameras at MSSS as well as the available video processing equipment which can be used for special applications. Most of these TV cameras are dedicated to particular sensor system applications.

Video Tape Recording

Recording of AMOS video is accomplished standard U-matic video cassette recorders.

Recorders used include Sony and Panasonic 3/4-inch U-matic SP video cassette recorders which are used for a range of dedicated applications. These are used for routine mission support and in applications where supplemental recorded data is required. The U-matic recorders are mounted in a large double rack in the control room. Before any mission, one person can make sure every sensor using video tape has a fresh cassette in place in its recorder. For viewing with standard high quality television monitors, 3/4-inch tape permits several generations of video processing and editing before sensible image degradation occurs.

Video Annotation

The purpose of video annotation is to automatically record operator selected settings (which filter is in place, what field-of-view has been selected are examples of settings) as a function of time on the video tapes produced by sensors that make television-like images. The "housekeeping" information is recorded permanently between frames thus becoming part of the data. The IRIG-B time is recorded on the audio channel. In playback, the data is presented alpha-numerically superimposed on the frame if desired. Comparing video taped events with the mount-history data is simplified and unambiguous.

Figure 5-3 is a block diagram of the method of recovering the annotated information. Note that all or portions of the information can be re-recorded to appear in the picture area permanently if desired.

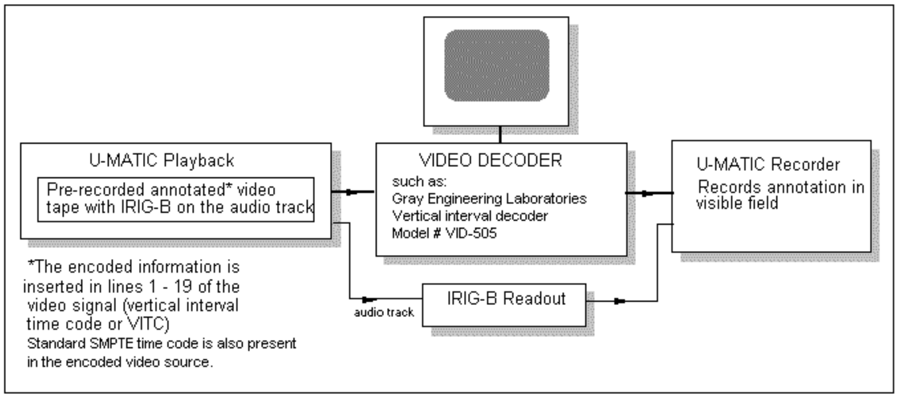

Figure 5-3, Video Annotation Recovery

OCS Upgrade

The OCS video system provides for the distribution, annotation and recording of video signals, all under software control. The distribution of video signals will be by a set of video switch matrices. One switch matrix will be provided for each of single operator stations. A central switch matrix which is used for routing between telescopes will be installed at the MTO console. Each STO will have an associated set of video tape recorders (VTRs) which can be controlled via the VMGT software. Also each set of telescope video will have software controllable annotation hardware which will allow for the annotation of information onto video signals.